**Study of the Effects of Operating Turbine Fuel Systems at Low Temperatures**

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Jet aircraft are currently limited to operating at measured fuel temperatures that are greater than 3°C above the fuel specification freeze point. This limits fuel temperatures to -37°C for Jet A fuels (-40°C specification freeze point) and -44°C for Jet A-1 fuels (-44°C specification freeze point). The recent opening of long duration, polar routes results in fuel being subjected to lower temperatures for longer periods of time. When the measured in-tank fuel temperature approaches these low temperature limits, pilots are forced to modify flight path, altitude, and/or airspeed to raise these temperatures.

Many jet fuels have freeze points which are significantly lower in temperature (2 to 15°C) than the fuel specification. Currently, these fuels are subjected to the above specification limits, despite the fact that these fuels will not freeze unless subjected to significantly lower temperatures. Airline companies would like to change the low temperature operation limit to greater than 3°C above the measured freeze point of the particular fuel being used, rather than greater than 3°C of the fuel specification freeze point. Such a change could minimize unnecessary flight path, altitude, and/or airspeed alterations.

We have undertaken the study of the effect of operating fuel systems at temperatures greater than 3°C of the actual measured freeze point of the fuel sample. We have designed and built an aircraft wing tank simulator which can be subjected to low temperatures inside an environmental chamber. The simulator employs actual B747 fuel boost pump and flapper valves. The fuel flow rates, fuel temperature profiles, pump current, and pressure drop across the pump are measured as function of the environmental chamber temperature.

We have also performed a series of laboratory studies to better characterize fuels at these low temperature. These include differential scanning calorimetry; low temperature scanning Brookfield viscometry; and freeze, cloud, and pour points. In particular, the change in viscosity at these low temperatures is especially significant for operation of the fuel system. We have also studied the mixing of two fuels with different freeze points. Such fuel intermingling occurs routinely upon aircraft refueling, and can be problematic if the freeze point of the resulting fuel mixture is higher than either of the two original fuels. In addition, we have undertaken a computational fluid dynamics study of our wing tank simulator to allow prediction of fuel temperatures in real fuel systems.